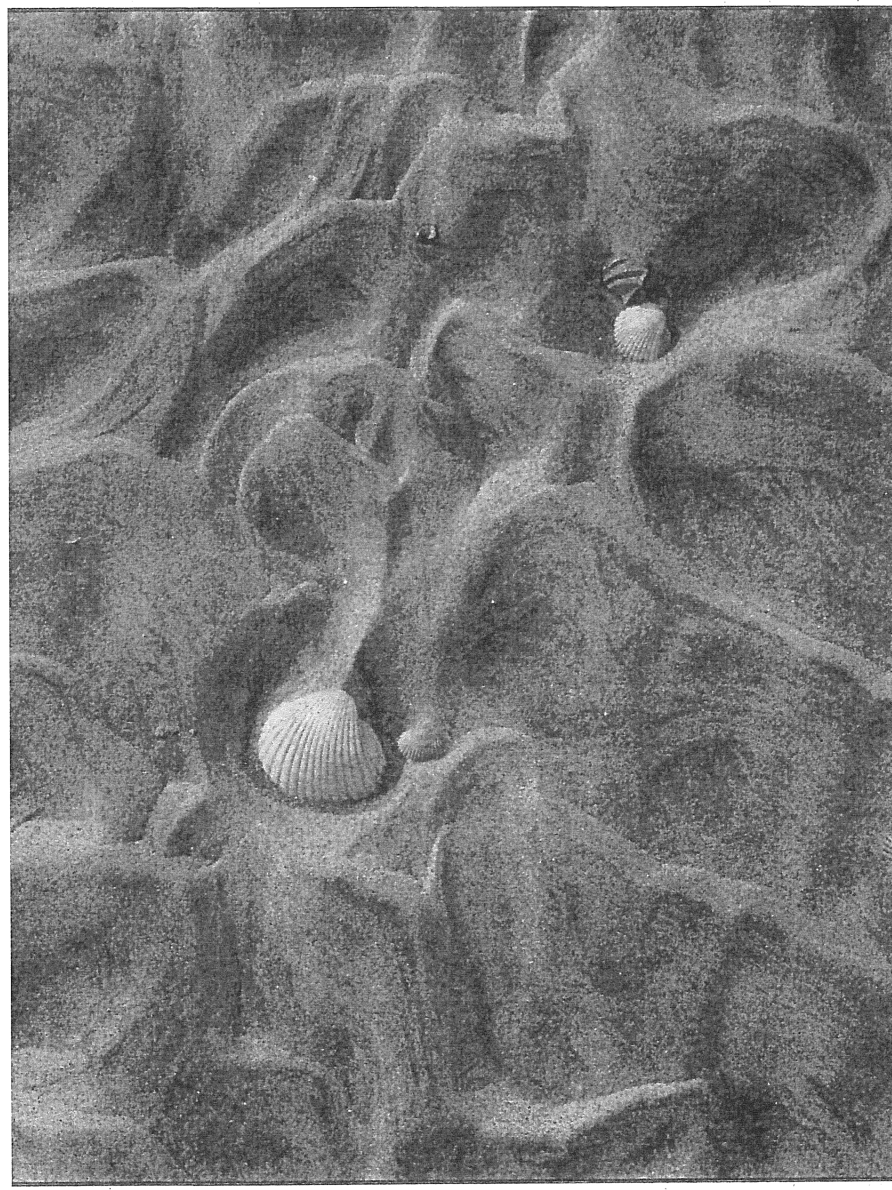
SOUTH CAROLINA COASTAL COUNCIL

Conserving What We Can't Create

CONSERVING SOUTH CAROLINA BEACHES THROUGH THE 1990s:
A CASE FOR BEACH NOURISHMENT

by Timothy W. Kana, PhD



Acknowledgments

Information used in developing South Carolina's beach nourishment needs for the 1990s comes from many sources. In addition to the South Carolina Coastal Council's network of beach survey stations established around 1987, early data from the U.S. Army Corps of Engineers and privately contracted surveys from Seabrook, Kiawah, and Wild Dunes were particularly helpful. The erosion database from the City of Myrtle Beach is one of the most detailed available and has provided before and after results in connection with its nourishment projects.

Virtually every nourishment project attempted in South Carolina has been controversial to some degree and would not have been completed without the persistence of certain community leaders. The author thanks the mayors, council persons, and property owners' representatives who have risked their reputations in support of projects which undoubtedly were uncertain in their outcomes. The South Carolina Coastal Council commissioners and staff of the regulatory agencies that review nourishment projects are also thanked for their diligence during the permitting process.

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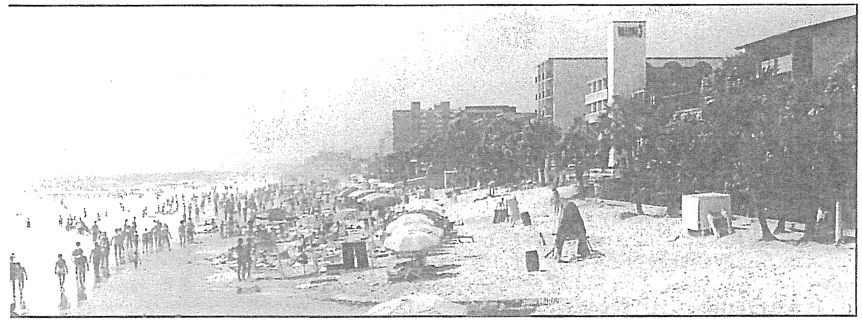
About the Author

Timothy W. Kana is president of Coastal Science & Engineering, Inc., and adjunct professor of geology at the University of South Carolina. He is a 1971 graduate of the John Hopkins University and received his doctorate in coastal processes from the University of South Carolina in 1979. During the past decade, he has conducted research and planned beach restoration projects throughout the South Carolina coast as well as sites in New York, Texas, the Caribbean, West Africa, and Kuwait.

Dr. Kana and his company have been involved in the planning of over half the beach nourishment projects in South Carolina since 1980, including five emergency projects following Hurricane Hugo. Other recent experience includes a $1.5 million nourishment project at Seabrook and a feasibility study for renourishment of Hunting Island. He has served as an expert witness on beach erosion and has assisted the South Carolina Coastal Council in developing the methodology for establishing baselines and setback lines under the 1988 Beach Management Act.

CONSERVING SOUTH CAROLINA BEACHES THROUGH THE 1990s: A CASE FOR BEACH NOURISHMENT

Synopsis



SHIFTING SANDS ARE A NATURAL, INTEGRAL part of any beach, but this movement, when coupled with development, can cause problems. Approximately one-half of South Carolina's 90 miles of developed shoreline is eroding or lacks a dry-sand beach due to the homes, businesses and seawalls built too close to the ocean.

The Beachfront Management Act of 1988 and 1990 was a first step in addressing this problem. Construction setbacks were mandated and new erosion control structures outlawed. This policy of retreat will have a positive impact on most developed and undeveloped beaches, but landward movement is not feasible for all coastal communities given the size and investment of the current oceanfront development. Beach nourishment may be the only alternative if these beaches are to be preserved.

"Conserving South Carolina's Beaches" gives an overview of the nourishment needs of this state. The document outlines almost 20 nourishment projects and includes recommendations regarding construction methods and sand sources. Although revisions are to be expected when the time comes to implement specific projects, the cost estimates provide a preliminary guide for ranking projects and relating them to the value of existing development or costs of other shore-protection alternatives.

The author estimates it will take 16 million cubic yards of sand (approximately 100 football fields, each filled with a 100-ft high pile of sand) at a cost of about $65 million to restore and maintain a minimum dry-sand beach along the state's eroded coast over the next ten years. Areas such as Hunting Island and Folly Beach will require expenditures up to $500 per linear foot, while stable beaches such as Myrtle Beach will require less than $100 per foot.

Because the needs of an area and the response to nourishment are never identical, beach nourishment will not be the answer to every erosion-related problem. Experience, however, is the best guide and is leading to better results. By combining nourishment with the state's current coastal retreat policy, South Carolina's beaches can be just as beautiful 100 years from now as they are today.

Beach Conservation Alternatives

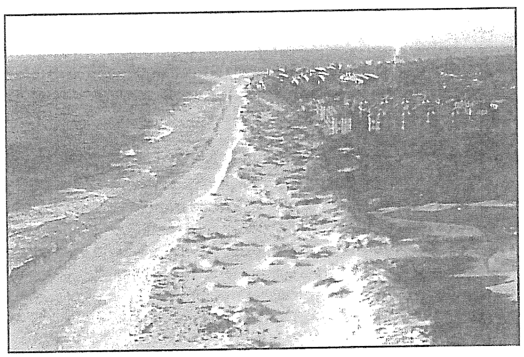
THE FOCUS OF THIS BOOKLET IS ON conserving South Carolina's almost 200 miles of sandy beaches. This is already being done in many ways.

Preservation. Over 40 percent of South Carolina's coastline is preserved as wildlife refuges or public parks. Other than a few nature interpretation centers and support facilities, these areas will never be developed.

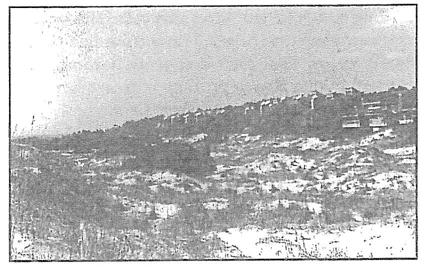
Natural accretion. About 20 percent of our coast is developed and gaining sand. On Sullivans Island, the beach is building because jetties trap sand that would otherwise go elsewhere.

Setbacks for development. Ten percent of our coast is privately owned and open to future development. Through South Carolina's Beachfront Management Act, these coastal lands are now subject to greater setbacks from the ocean than in previous times. Setbacks do not necessarily reduce property values. Kiawah Island resort, a leader in land planning and oceanfront setbacks long before the Beachfront Management Act, is a good example of this.

Abandonment. Before federal flood insurance became widely available in the early 1970s, abandonment was common. Property owners built along the coast at their own risk; private insurance companies did not want to insure homes built near the ocean. Today's flood insurance program is undergoing changes, encouraging oceanfront property owners to once again move landward or build at their own risk.

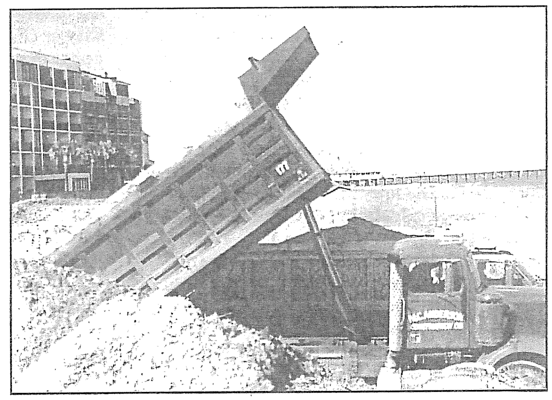


Armoring. Lining the shore with seawalls and revetments is a second shore-protection alternative of the past. By some estimates, the state has about 20 miles of developed, armored beaches. In almost every case, the cost of such shore protection has been covered by individual property owners at costs ranging from $20,000 to $100,000 per 100 feet of shoreline. An estimated $30+ million has been spent on seawalls in South Carolina since the mid 1970s. The investment such structures protect is surely 10 to 100 times greater.

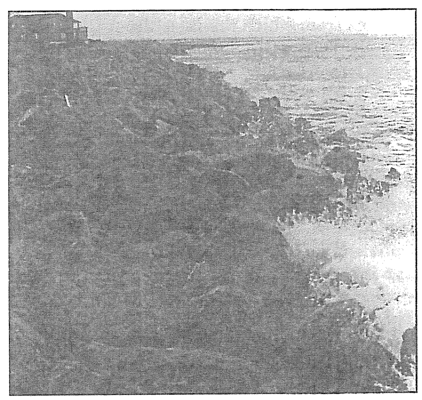


State laws now severely limit this option for a number of reasons. Seawalls hold the line against an advancing sea at the expense of the recreational beach. Walls built where primary sand dunes once stood invariably conflict with the natural exchange of sand between the beach and dune system. In many instances the dry-sand beach is lost. Aside from the intangible cost to the public beach, such armored shorelines lose appeal, impact community property values, and produce a smaller buffer between storm waves and buildings.

Beach nourishment. Beach nourishment involves the placement of sand on the beach by artificial means in an attempt to offset losses due to natural erosion, an artificial accretion of sorts. This doesn't mean nourishment stops erosion. A nourished beach is just as dynamic as a natural beach.



Until 1980, very few nourishment projects were attempted in South Carolina — Hunting Island and Hilton Head Island being the largest — but the technique has found widespread use in the United States for several decades. It is the only alternative that at once conserves the public's recreational beach and the private, upland areas.



It appears that, by default, beach nourishment will be a favored shore-protection measure of the 1990s. To understand the complexity of this solution, we need to share a common frame of reference and learn what constitutes a healthy beach.

A Technical Look

Defining a Healthy Beach

A healthy beach has three components: the broad, sandy shoreline encompassing vegetated dunes; a flat, dry-sand beach where we place our beach chairs and blankets; and the wet-sand beach where we wade through the breakers. As long as all of these features are in place, we perceive a beach as being healthy.

South Carolina has a wide spectrum of beach conditions, ranging from exceptionally healthy areas to pathetically eroded areas armored with seawalls. In extreme cases, even the wet-sand beach is missing, replaced by a seawall.

The methodology used to implement the Beachfront Management Act established an objective way to determine the relative health of a beach. Methodology prescribed in the act includes mandatory surveys of the beach from the dunes to the low-tide breaker line. This profile allows calculation of the quantity of sand on each beach. (Diagram 1)

The beach begins at the most seaward dune crest or seawall and extends to low-tide wading depth. The volume of sand contained in a 1-ft slice of the beach can be compared with other beach sections measured to the same depth of water. Diagram 1 shows the typical occurrences on the South Carolina coast. A healthy profile, portrayed in the middle diagram, contains 100 cubic yards per linear foot (cy/ft). (Due to differences in grain size, wave energy, and beach slopes, healthy profiles in the Grand Strand will have around 80 cy/ft whereas healthy profiles at Hilton Head Island typically contain at least 120 cy/ft).

When seawalls or revetments replace sand dunes, the volume remaining on the beach may only be 50 cy/ft as shown on the upper diagram. The beach is said to be "armored" and may not contain any usable beach area around the time of high tide each day. It has a certain sand deficit compared to healthy beaches.

At the other extreme are beaches containing much larger sand volumes (the lower diagram) because of sand bars attached to the beach at low tide. This is especially common around inlets. Beach profiles indicate how much extra sand exists beyond a normal profile.

The middle profile represents an average that is the minimum desirable sand volume for a particular beach out to low-tide wading depth. It includes a natural dune, dry-sand beach, and wet-sand beach. Litchfield Beach has an unarmored profile similar to the middle diagram, whereas the north end of Garden City or Cherry Grove looks more like the upper diagram. Profiles from the accreting areas of Sullivans Island would look like the lower diagram.

It is obviously the beaches with a sand deficit that present the most problems. There are two ways to increase the size of such beaches: (1) remove the seawall, vegetation, and any building close to the ocean and allow a high-tide beach and dune to adjust naturally, or (2) nourish the beach in front of the seawall and artificially create a healthy profile.

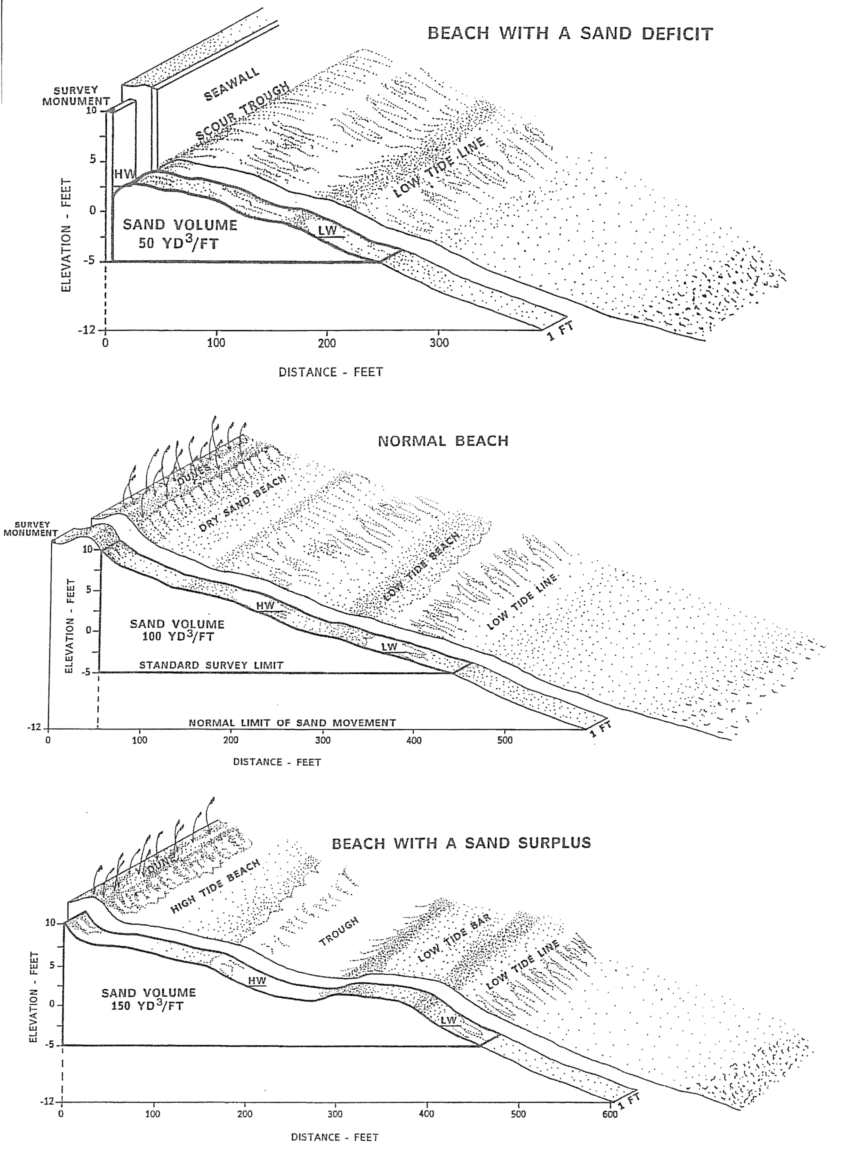
Computing Sand Volumes

If nourishment is the means by which the beach is to be preserved, the technical components from which the Beachfront Management Act is administered can help determine where and how much sand is needed. To understand this, one must understand the mechanics behind the legislation.

The Beachfront Management Act created baselines and setback zones. Baselines are found at the crest of the primary, oceanfront sand dune. It is from this location the setback is measured. In cases where there are seawalls and no dunes, the position of the baseline is based on a projection of where the dune would stabilize if the seawall was removed. This is determined using beach profiles like those shown in the previous section.

The setback lines relate to the expected

Diagram 1



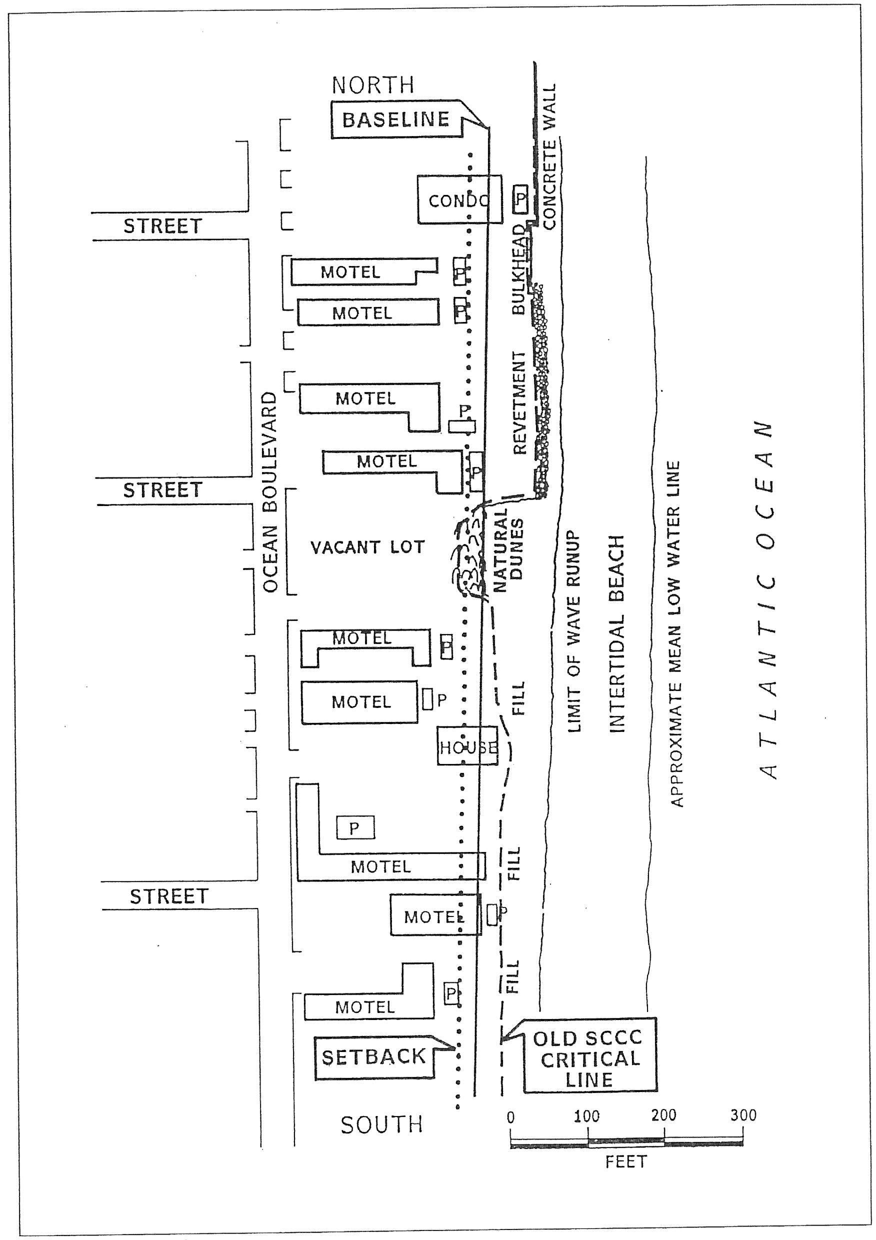
erosion rate over the next 40 years, an arbitrary period selected for planning purposes and prescribed by the Beachfront Management Act. The setback line is measured from the baseline and is found by multiplying an area's annual erosion rate (for the past 40 years) by 40. Semiannual surveys or profiles are taken to determine the movement of the beach and the eventual placement of the setback line. Within the setback, limited construction may occur. In front of the baseline, a special permit is needed from the South Carolina Coastal Council before construction may begin.

Diagram 2 depicts a small section of the Grand Strand and shows how the baseline can impact certain properties more than others depending on the volume of sand on the beach, presence or absence of seawalls, and the setback of individual buildings.

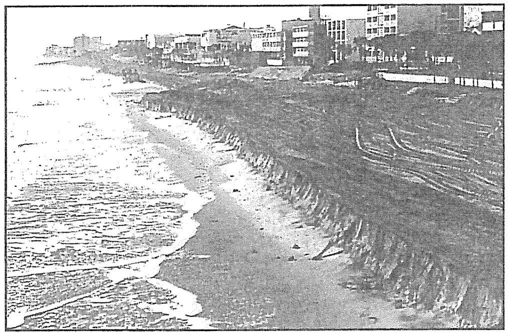
With the exception of unstabilized inlet zones, simple inspection of the South Carolina Coastal Council's maps showing baselines and setback lines point out where the greatest initial nourishment requirements occur (i.e., where baselines encroach farther inland) and where the greatest maintenance nourishment requirements are (i.e., where baselines and setback lines are further apart). It is through review of the South Carolina Coastal Council's beach survey data, baseline positions, setback lines, and experience with prior projects that the nourishment estimates in this booklet are made.

Look again, for example, at Diagram 1. The top example, the armored beach, would require nourishment of 50 cy/ft to achieve the size and shape of the healthy beach shown in the middle diagram; however, extra sand must be added to this quantity to build up the underwater part of the profile. The extra sand, which may be one-half the initial nourishment requirement, is needed to support the high-tide beach. In other words, a foundation is needed to support the dunes and the dry-sand beach just as a first floor is needed to support the second floor of a house.

Predictions regarding maintenance requirements can be made by reviewing the data used to establish the setback lines. Erosion rates measured by the feet of shoreline retreat per year can be converted to a volumetric erosion rate if the slope and width of the beach profile are known. A 2 ft/yr erosion rate, for example, may equal a volume loss of 4 cy/ft/yr. This gives a measure of the annual maintenance nourishment requirement for a given beach.



A General Approach to Beach Nourishment



THE SUCCESS RATE OF BEACH NOURISHMENT projects around the world has been varied. Some have lasted for many years while others have eroded in a few months. Professionals generally regard the following qualities essential for success:

Beach quality sand should be used. If the sand placed on a beach matches what is already there, the new sand will mimic that beach's "natural" response to waves and tides. If the grains are too fine, they will wash out to sea faster than the natural sand. Good quality sand, free of mud, generally causes the fewest negative environmental impacts and works best.

Long projects work better. Consider what would happen if only one oceanfront lot is nourished. The extra sand would bulge out from the shoreline, inviting waves to attack it. The result would be a tendency for the sand to spread along the beach in either direction. If 100 lots are nourished at the same time, the natural tendency for the artificial beach to unravel from its ends will take longer to impact properties in the center.

Nourishment of the entire beach profile works best. Because the beach profile is like an iceberg with much of its volume under water, nourishment must allow for some sand to move past the low-tide mark. Without this foundation, the high-tide beach will never be stable. Waves and tides will reshape the new sand into the same slopes contained in the natural beach.

Allow for natural losses along the shore. Sand often moves in a preferred direction along the coast. In South Carolina, this movement is generally southerly, except near inlets where northerly movement can also occur. Successful projects account for the natural sand transport system and can sometimes use it to an advantage.

A low erosion rate is desirable. Nourishment will last longer where erosion rates are lowest. Where erosion rates are exceedingly high, nourishment may not be the best solution in the long run.

The cost of sand is reasonable. All else being equal, sand costing $1/cy to deliver and spread on the beach works just as well as sand that costs $10/cy. The cheapest beach-quality sand is usually the best deal as long as it is derived from a source other than the beach itself. This may include offshore deposits, inland deposits, and in some cases, inlet deposits where accretion is the natural trend.

The wide range of conditions, erosion rates, and sand sources for nourishment projects along the South Carolina coast mirror the wide range of project costs. Some cost as little as $.50/cy, whereas others have reached as high as $12/cy. But the cost of sand alone cannot be the deciding factor when considering a beach nourishment project. For example:

Each year, Beach A is losing one cubic yard of sand for every foot of beach (1 cy/ft/yr). Due to the location of beach-compatible sand for nourishment, the best price Beach A can get is $6.00/cy. Beach B is losing 8 cy/ft/yr, eight times more erosion than Beach A, but has a nearby sand source, bringing the cost of sand down to $2.00/cy. Renourishing Beach A, even though the cost of the sand is three times greater, is certainly a better buy.

During the 1980s, nourishment projects spanned a wide range of costs (Table 1).

TABLE 1. Range of costs for beach nourishment projects.

	Erosion Rate	Equivalent Volume	Example
South Carolina Erosion Rates:	<1 ft/yr	1 cy/ft/yr	Myrtle Beach
	~3 ft/yr	4 cy/ft/yr	Central Debidue
	~6 ft/yr	8 cy/ft/yr	Central Hilton Head

	Volume	Example
Initial Nourishment Requirement to restore previous losses and produce a 50-ft dry-sand beach seaward of seawalls/eroding dunes	10 cy/ft	North Myrtle Beach
	25 cy/ft	Edisto Beach
	45 cy/ft	Fripp Island
	65 cy/ft	Folly Beach

Unit Costs of Borrow Sand	Haul Distance	Cost $/cy	Example
• By trucks from low-tide bars in accretion zones	<1,500 ft	1.25	Wild Dunes (1983)
	~5,000 ft	2.00	Pawleys Island (1988)
	~15,000 ft	4.00	North Myrtle Beach (1989)
	~35,000 ft	6.00	North Myrtle Beach (1989)
• By trucks from inland sand sources	<2,500 ft	3.00	DeBordieu (1990)
	~5-10 mi	5.50	Myrtle Beach (1987)
	~5-10 mi	6.50	Myrtle Beach (1990)
	~15 mi	8.00	North Myrtle Beach (Bid)
• By dredge from offshore shoals	<5,000 ft	2.50	Seabrook (1990)
	~5 mi	4.00	Hilton Head (1990)

EXAMPLE 10-YEAR NOURISHMENT COST RANGE FOR A 1-MILE PROJECT IN SOUTH CAROLINA

	Typical Low Range	Typical High Range
Initial nourishment volume	10 cy/ft	60 cy/ft
Annual maintenance x number of years	1 cy/ft/yr	8 cy/ft/yr
Unit cost of sand	$2.00/cy	$6.00/cy
Volume required (10 years)	~20 cy/ft	~130 cy/ft
Cost/ft of shoreline	$40/ft	$780/ft
10-year cost/mile (w/o interest)	**$210,000/mi**	**$4,539,600/mi**

Hunting Island and Myrtle Beach are two examples. Hunting Island has an erosion rate estimated as high as 20 ft/yr. The 1980 nourishment project at this beach cost about $175/ft ($2.50/cy) and added about 70 cy/ft. It is considered unsuccessful by some because most of the fill washed out of the project area within five years.

Myrtle Beach, in contrast, has a comparatively low erosion rate of 1 ft/yr. A 1987 project costing $105/ft ($5.55/cy) added around 20 cy/ft or 30 percent of the unit quantity placed on Hunting Island. Several more years of monitoring are required before its performance can be objectively compared with Hunting Island. Projects at Seabrook Island and Isle of Palms offer two examples of successful nourishment completed during the past decade (see side bar).

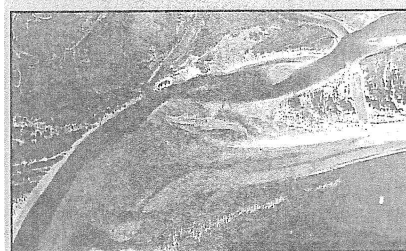
Innovative Projects at the Isle of Palms and Seabrook Island

Isle of Palms and Seabrook Island provide two of the most dramatic examples of erosion and beach restoration in South Carolina in the past decade. The north end of each island is influenced by an inlet and offshore bars which control the supply of sand to the beach and the distribution of waves along the shoreline.

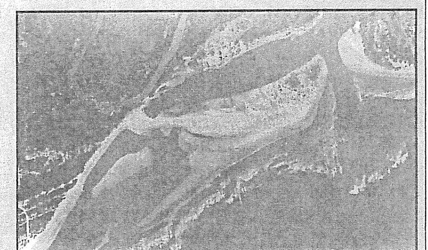
Seabrook was experiencing severe erosion as an inlet to the north (Captain Sams) began moving south, taking many of the Island's sand dunes with it. In 1983 the inlet was relocated to the same place it existed across Kiawah spit in 1963, about 1.5 miles to the north. By artificially closing the channel that was causing erosion along Seabrook and opening a new inlet farther north, sand in offshore bars was freed from the inlet to be pushed ashore by waves and restore over 1 million cubic yards. Today, Seabrook's north beach is about 1,000 feet wide in front of the seawall.

The north end of Isle of Palms is the site of the Wild Dunes Resort. It is also influenced by a nearby inlet (Dewees Inlet) but, unlike Seabrook, does not have to contend with continual southerly migration of the channel. Dewees Inlet is deeper and stabilized in an old river bed. It is the island's offshore bars that cause problems along the beach from time to time. In 1982, a sand bar detached from the delta of Dewees Inlet and moved onshore by waves literally pushing the sand up the beach. This form of natural nourishment was of great benefit to one part of Wild Dunes. Over 500,000 cy were gained by natural accretion along a 2,000 foot section of beach. The down side of the one-quarter-mile-wide bulge the sand bar produced was the severe erosion it caused just up the beach at Mariners Walk Villas.

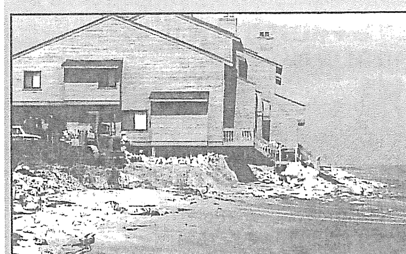
By late 1983 the problem was so severe property owners had to build a seawall to prevent damage to their condominiums. A nourishment project was completed soon afterwards by pumping sand from a nearby marina basin. By placing the nourishment sand in the erosion zones between the areas of rapid accretion, the shoreline was straightened. This lessened the tendency for one area to erode more than another and helped restore the entire beach by several hundred feet. Today the seawall is buried well inland of the new Mariners Walk beach.



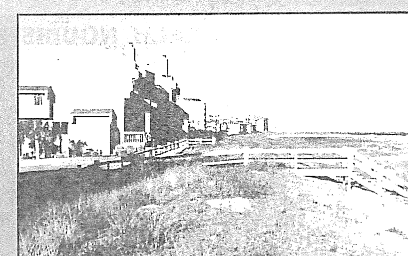
Seabrook Island in 1983, during the first stage of the inlet relocation project.



Same area of Seabrook after the channel was closed and the new inlet (1.5 miles north) was opened.



Isle of Palms homes threatened by erosion.



Same area of Isle of Palms several years after a beach nourishment project.

Nourishment In The 1980s

PRIOR TO 1980, FEW BEACH NOURISHMENT projects were attempted in South Carolina. Myrtle Beach and other parts of the Grand Strand were restored after Hurricane Hazel in 1954, but this effort consisted of bulldozing dunes into place and hauling sand from washovers back to the beach. Edisto Beach was nourished in the mid-1950s using sand dredged from a basin on the lagoon side of the island. Palmetto Dunes, a private resort along the middle of Hilton Head Island, nourished its beach in 1969 with sand excavated to create a system of freshwater ponds. In 1980, the same beach was renourished using sand pumped from a marina basin on Broad Creek.

Hunting Island, the only federally authorized nourishment project in South Carolina prior to 1975, was first nourished in 1968 and renourished in 1971, 1975, and 1980. The frequency of the project and its rather substantial volume (3.5 million cubic yards in 12 years) probably contributed to a common perception that beach nourishment is a temporary and costly alternative for conserving beaches.

By 1980, additional beach survey data were available for South Carolina. It became clear that shoreline change rates vary widely from place to place. Hunting Island may have required millions of yards of sand to keep pace with its high rate of erosion, but that didn't mean every beach in South Carolina would require the same amount. Islands such as Kiawah were accreting while others were eroding by various degrees. Outside South Carolina, nourishment projects such as the one along Miami Beach, Florida (1976-1980) were demonstrating that nourishment can be successful in terms of longevity, benefit-to-cost ratio, and quality of the artificial beach.

Perhaps in recognition of certain nourishment successes and a growing awareness that seawalls (as typically constructed in South Carolina) do not always provide protection from storms, beach nourishment became more common in the 1980s. Table 2 and the pie chart illustrate the 25+ miles nourished in South Carolina between 1980 and 1988. These projects cost $12.6 million and involved 5.5 million cubic yards of sand. This works out to an average expenditure of about $94/ft of shoreline (compared to $300-$700/ft, the cost range for typical seawalls in South Carolina).

There are several ways to review the costs of these projects. The most expensive was Myrtle Beach's $4.5 million nourishment project in 1986-1987. Three factors accounted for its high cost: a length of over eight miles, a total volume of 853,000 cy, and a high unit

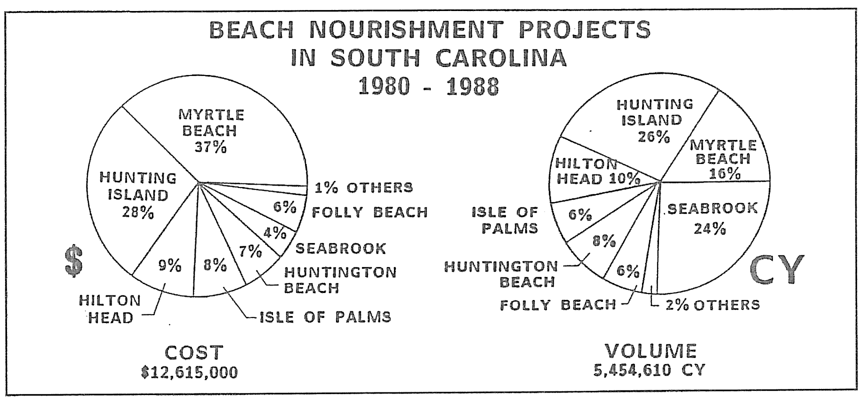


TABLE 2. Beach nourishment projects completed 1980-1988.

Funding	Locality (Completion Date)	Length (ft)	Volume (cy)	Total Cost	Cost/cy	Cost/ft	Method
Local (room tax) + emergency funding	Myrtle Beach (1987)	45,000	853,350	4,750,000	5.55	104.63	TR (E)
Federal/inlet maintenance	Huntington Beach (1988)	10,000	450,000	est. 900,000	2.00	90.00	DR (E)
Town/state emergency fund	Pawleys Island (1988)	15,000	53,000	100,000	1.89	6.67	Pans (AS)
Private	Isle of Palms (1982-1983)	4,000	175,000	175,000	1.00	43.75	Pans (AS)
Private	Isle of Palms (1984)	5,000	350,000	1,000,000	2.86	200.00	DR (E)
Federal (6 projects)	Folly Beach Park (1982-1988)	1,000	305,560	est. 500,000	1.64	500.00	DR (E)
Private	Seabrook Island (1982)	3,000	75,000	90,000	1.25	30.00	Pans (AS)
Private	Seabrook Island (1983)	6,500	230,000	300,000	1.30	46.15	Pans (AS)
Private	Seabrook Island (1983)	est. 10,000	1,000,000	200,000	0.20	20.00	Inlet Relocation TR (E)
Federal	Hunting Island (1980)	20,000	1,412,700	est. 3,500,000	2.50	175.00	DR (E)
Private	Hilton Head Island (1980)	15,000	550,000	1,100,000	1.82	66.67	DR (E)
	[25.5 mi]	134,500 ft	5,454,610 cy	$12,615,000	$2.31/cy	$93.79/ft	

TR = trucks. DR = dredge. E = external sand source. AS = accreted shoals. [Source: Coastal Science & Engineering, Inc., August 1989] cost of sand at $5.55/cy. The nearest available beach-quality sand was over five miles inland and had to be trucked in at a high cost. However, in terms of total expenditure per foot of shoreline, the Myrtle Beach project was close to the median for all projects in the 1980s.

The Hunting Island project involved the most sand but half as much shoreline as Myrtle Beach, making it more costly per foot. The Wild Dunes (Isle of Palms) nourishment project was the second most costly because it was limited to a 5,000 foot reach, but the project did produce over 500 feet of new dry-sand beach. The Seabrook project was the most cost-effective in terms of the volume provided per foot of beach. Seven years after a neighboring inlet was relocated, Seabrook's north beach is over 1,000 feet wider than before.

The point of these comparisons is to show the wide range of costs and performance of projects during the 1980s. Some worked and others did not or were too small to make much difference, as was the case of the 1988 Pawleys Island project. Each project, the successful as well as the not-so-successful, provides a benchmark against which future projects will be measured.

Before Hurricane Hugo (September 1989), the South Carolina Coastal Council solicited applications for funding under the $10 million Beach Nourishment Fund approved by the General Assembly in 1988. A total of $27.7 million was requested for projects covering Folly Beach County Park, Edisto Beach, Grand Strand, Hilton Head Island, Myrtle Beach, Pawleys Island, Edisto Beach State Park, and Hunting Island State Park. The allocation of state funds was as follows:

Town of Hilton Head	$6.25 million
Hunting Island	$1.80 million
Grand Strand	$0.73 million
Edisto Beach	$0.65 million
Pawleys Island	$0.30 million
Folly Beach County Park	$0.25 million

The bulk of the beach nourishment funds was earmarked for Hilton Head because that project was further along in planning and design. After Hurricane Hugo, the awards were returned to the state to be used for emergency work after the storm.

Hurricane Hugo and Beach Nourishment

On September 21, 1989, Hurricane Hugo destroyed almost every foredune and redistributed sand offshore or in washovers along every beach in South Carolina north of Kiawah. While the hurricane caused tremen-dous damages to the state, the storm and its effects on beach erosion should be placed in context:

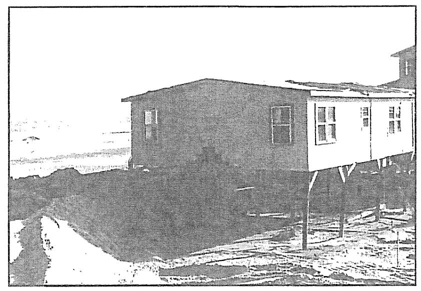
- Great storms are rare and simply intensify or accelerate the normal rate of change.
- Much of the erosion observed after storms is the temporary shift of sand from the dunes to low-tide bars as the beach flattens and absorbs heavy wave action.
- Most of the sand washed offshore will come back to the beach although it may take several years for a complete recovery. Some of the returned sand may be found elsewhere down the beach.

A sand loss of immediate concern after Hugo was sand dunes washed inland– washovers. While this added elevation to private property, it removed sand from the active beach system. At Garden City and Litchfield Beach, the quantity of sand lost to washovers may have equaled the 1987 Myrtle Beach nourishment project.

Even though erosion from Hugo should be viewed as a short-term event, South Carolina's beaches were in need of immediate attention. Exceptionally high tides were predicted to occur a month after the storm. If these tides were accompanied by winds from the northeast, many remaining beach structures would likely have sustained damage.

South Carolina's response to this post-Hugo threat included an immediate effort to rebuild protective sand dunes. Three weeks

after the storm, 65 miles of emergency dunes were scraped into place using sand from the wet-sand beach and sand plowed from the yards and streets of coastal communities. The



few weeks of bulldozer work required by this project was the equivalent of two years of dune building by natural processes. These dunes protected the beach and private property behind the beach during the succeeding high tides. Furthermore, the pushed-up dunes created a base on which natural dunes could build. The impact of this effort can be seen one year later in miles of foredunes protected by sand fences and the first sprigs of vegetation. (While this effort was successful in most areas, for about 20 miles of the coast, including Cherry Grove, Folly Beach, and the northern portion of Garden City, dune-scraping was not enough. These beaches were armored and lacked a dry-sand beach prior to Hugo. After the storm, there wasn't enough sand left to scrape or a beach wide enough to support a sand dune.)

After the dune-building project, five emergency nourishment projects were authorized by the Coastal Council. (Table 3) These were designed around a minimal volume to restore the beaches to pre-storm levels. Construction began in November. By March 1990, the projects at Pawleys Island, North Myrtle Beach, and Myrtle Beach were complete. Surfside and Garden City projects were finished by late April. Even though this work was the result of an emergency situation, these projects provide additional cost and experience data from which nourishment needs in the 1990s may be estimated.

The expenditures for the emergency beach work were almost $10 million, with an average cost of approximately $70 per linear foot (10-25 percent of the typical cost of South Carolina's seawalls). The State of South Carolina covered about 60 percent of the cost with the federal government and local interests covering the remaining 40 percent.

Projects on the Drawing Board

There were six nourishment projects in the planning and design stage in 1989. (Table 4) The Grand Strand project designed by the U.S. Army Corps of Engineers is the largest, encompassing three separate projects and over 22 miles of shoreline from North Myrtle Beach to Garden City. At $45 million, it dwarfs all other projects in South Carolina and would involve almost 5 million cubic yards of sand. As Table 4 shows, unit costs are estimated at $8.75/cy to $9.75/cy, or $360 to $400 per linear foot for the three communities.

A second federal project involves Folly Beach. As formulated, it would cost $5.6 million for about 1 million cubic yards of sand and would cover 3.2 miles of shoreline. Unit costs are estimated at $5.36/cy or $330 per linear foot.

Hilton Head Island began plans for its nourishment project in 1986. Construction began in April 1990 and was finished in August of that year. This project involved 2 million cubic yards of sand at a cost of $9.7 million, funded by local accommodations tax revenue, local taxes, and state funds. Unit costs were about $4.75/cy, or $277 per linear foot.

Seabrook Island was the sixth project. It was completed by hydraulic dredge in March 1990 at a cost of $1.5 million and involved 700,000 cy. Unit costs were $2.15/cy or $250 per linear foot.

TABLE 3. Emergency beach nourishment projects following Hurricane *Hugo*, 1989-1990 (final cost estimates, February 1990).

Locality	Length (ft)	Volume (cy)	Total Cost*	Cost/cy	Cost/ft	Method
North Myrtle Beach	27,500	377,200	1,937,000	5.14	70.44	TR (AS)
Myrtle Beach	44,700	380,000	2,667,600	7.02	59.68	TR (E)
Surfside	5,000	75,000	581,250	7.75	116.25	TR (E)
Garden City	13,500	200,000	1,640,000	8.20	121.48	TR (AS)
Pawleys Island	16,200	225,000	612,000	2.72	37.78	TR (AS)
TOTALS [20.2 mi]	**106,900 ft**	**1,257,200 cy**	**$7,437,850**	**$5.92/cy**	**$69.58/ft**	

TR = trucks. E = external sand source. AS = accreted shoals. *Including engineering.

TABLE 4. Beach nourishment projects planned (circa 1988-1995).

Funding	Locality (Design Date), Source	Length (ft)	Volume (cy)	Total Cost	Cost/cy	Cost/ft	Method
Federal(65%)/state/local	North Myrtle Beach[1] (1987) USACE	42,768	1,776,000	17,311,000	9.75	404.77	TR (E)
Federal(65%)/state/local	Myrtle Beach[1] (1987) USACE	46,464	1,931,000	16,856,000	8.73	362.78	TR (E)
Federal(65%)/state/local	Surfside/Garden City[1] (1987) USACE	30,096	1,250,000	11,081,000	8.86	368.19	TR (E)
Federal(>75%)/local	Folly Beach[2] (1987) USACE	16,860	1,038,000	5,562,500	5.36	329.92	DR (E)
Private	Seabrook (1989) CSE	6,000	700,000	1,500,000	2.15	250.00	DR (E)
State/local	Hilton Head Island[3] (1988) Town OA	35,000	2,036,000	9,700,000 (est.)	4.76	277.14	DR (E)
	[33.5 mi]	**177,188 ft**	**8,731,000 cy**	**$62,010,500**	**$7.10/cy**	**$349.97/ft**	

TR = trucks. DR = dredge. E = external sand source. [1]Totals for the 5-year project - first costs only (USACE 50-year storm design criteria). [2]Totals for the 5-year project - first cost plus one 5-year renourishment (USACE 50-year storm design criteria). [3]Totals for an 8-year project - annual erosion rate criteria plus initial deficit for north Forest Beach. Sources: U.S. Army Corps of Engineers (USACE); Coastal Science & Engineering, Inc. (CSE); Olsen Associates (OA)

Planning For Future Nourishment Projects

GIVEN THE VARIED NOURISHMENT EXPERIENCE along the South Carolina coast, it is necessary to assume a limited and common set of criteria before estimates are made for future nourishment needs. While we know the more sand placed on the beach the longer a project will last, resources are limited. Even if South Carolina had unlimited funds, more data on erosion and performance are needed before we risk large sums on long-range projects into the next century.

We can, however, make fairly accurate predictions for the near future. For our purposes here, a similar design life and level of protection for each project were assumed.

Design Life

Past experience suggests we can predict volumetric erosion rates and nourishment requirements in South Carolina over periods of less than ten years. Beyond ten years, there is uncertainty regarding the impacts of storms, the influence of tidal inlets, or the threat of accelerated sea-level rise. For this booklet, we adopted a design life of ten years and assumed natural processes, coastal storms, and tide levels will occur at the same rates as in recent times.

We define the ten-year nourishment requirement as follows: (1) The initial nourishment required to produce an average 50-foot-wide, dry-sand beach seaward of existing dunes or seawalls at an elevation equaling the highest tide and wave level in a typical year. Initial nourishment will include the extra volume needed below low tide out to a depth of 12 to 15 feet. Myrtle Beach's 1987 project used these standards. (2) The maintenance nourishment that is required to replace average annual sand losses for a period of ten years.

For illustrative purposes, imagine an armored shoreline with no dry-sand beach that contains about 85 percent of a normal sand volume and is losing 3 cy/ft/yr to erosion. The initial nourishment requirement is 25 cy/ft and the ten-year maintenance requirement is approximately 30 cy/ft. The initial nourishment would produce the minimum 50-foot wide, dry-sand beach. Maintenance nourishment would replace sand losses in succeeding years. This means the total nourishment requirement as defined above would be about 55 cy/ft at this site.

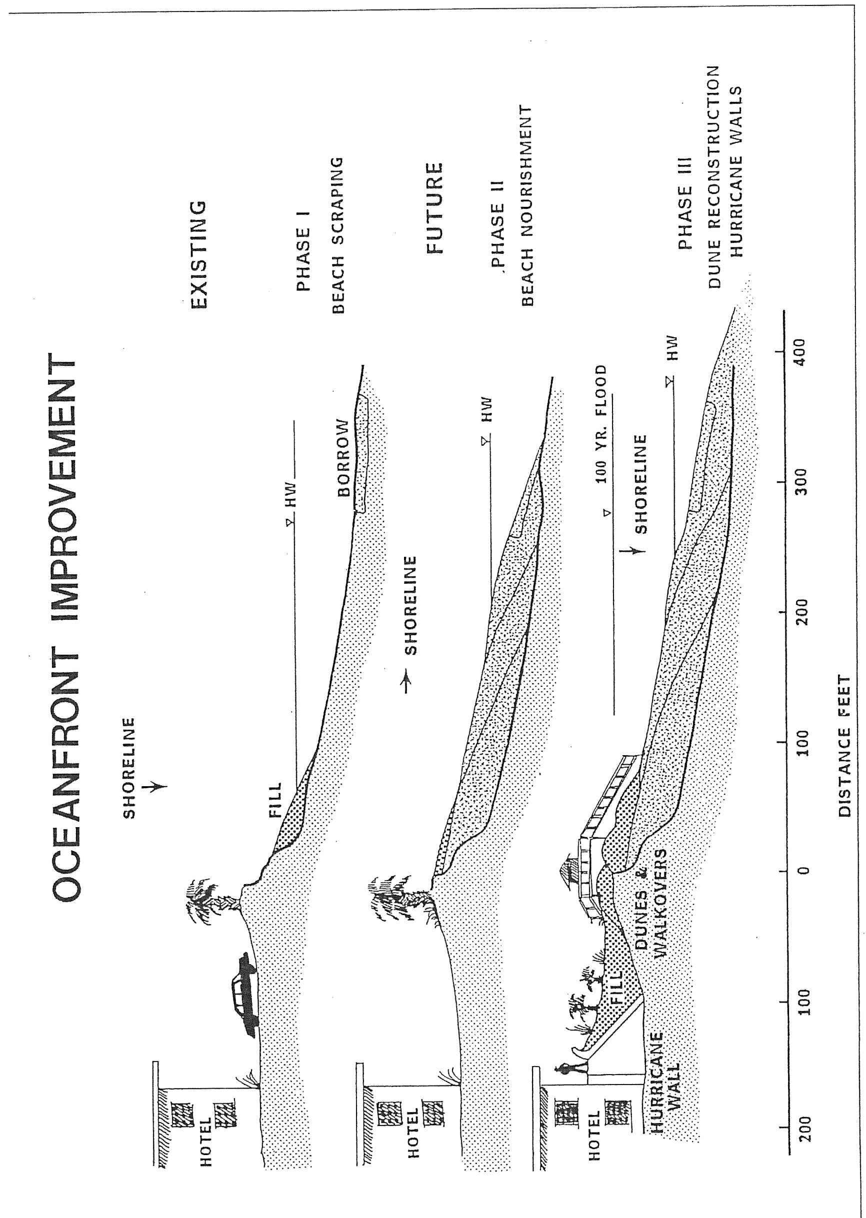
If the shoreline in question is 10,000 feet long, it would require about 550,000 cy of sand to maintain a minimal dry-sand beach over ten years. If sand can be delivered for $4/cy including related expenses such as engineering, mobilization, and monitoring, the project will cost about $2.2 million exclusive of interest. While this example is a gross simplification of the design process, it illustrates a common method for estimating the nourishment requirements for the entire state.

Level of Protection

The level of nourishment envisioned in the previous section falls within a range of beach restoration possibilities illustrated in Diagram 3. It would be more than beach scraping but fall short of absolute protection from storms.

Phase I of the diagram illustrates beach scraping. This shore protection measure is inexpensive compared to nourishment and can be implemented quickly, such as the case immediately after Hurricane Hugo. Beach scraping simply shifts sand along the profile and does not add to or subtract from the sand supply. The City of Myrtle Beach, prior to its nourishment project, scraped sand from the low-tide beach (labeled borrow on the diagram) and placed it against the shorelines' eroding scarps and seawalls. This helped for a short while and provided an alternative to armoring until a community-wide nourishment plan was implemented.

The middle diagram (Phase II) shows how a moderately nourished beach as envisioned in this booklet's proposed plan is built higher and more seaward than the existing profile. In this case, sand is brought in from an external source, adding to the volume of sand in the beach and, significantly, to the cost of the pro-



ject. It restores a dry-sand beach and provides more sand to absorb energy before waves strike the shore, but it does not provide an ultimate line of defense against large storms. Surges like the one caused by Hurricane Hugo will overtop the new beach and threaten structures close to the shoreline.

The lower diagram represents more permanent protection of the shoreline. It consists of beach nourishment, construction of dunes, and possible addition of a buried seawall to serve as a last line of defense during a major storm. This level of protection exists on some South Carolina beaches. Seabrook Island's north beach, for example, is protected by a massive seawall and nourished beach. Georgetown County's Litchfield-by-the-Sea, where one of the healthiest foredunes exists, can sustain a Hugo-level surge with negligible damages. This can be produced along any eroding beach, given sufficient sand and money. The permanent protection as described in the lower diagram is well beyond the level of effort envisioned in this booklet and possibly beyond the means of some of the coastal communities in South Carolina.

Estimate of Unit Costs

The projects constructed in the 1980s and recently planned (Tables 2-4) provide guidance for ten-year nourishment costs in the 1990s. The factors affecting costs are the initial sand deficit, volumetric erosion rate, source of sand, means of transfer, and transportation distance (Table 1). Estimates of needs have to link borrow sources and means of transport to specific nourishment sites. The primary borrow areas for beaches in South Carolina are assumed to be:

- **nearshore shoals**, especially those associated with ebb-tidal deltas (Hilton Head Island, Folly Beach, and Seabrook)
- **inland sand pits** (Myrtle Beach)
- **attached shoals** or low-tide bars in accreting zones (Pawleys Island, Isle of Palms)

Cost data are available for each type of project with the range falling between $1/cy and $10/cy (Table 1). It is generally accepted that large initial projects are often less expensive per yard than small nourishment or maintenance projects because start-up costs have to be apportioned over each nourishment. Unit costs for the 1990s are based on late 1980s experience with minimal allowance for inflation. For purposes of simplification, maintenance nourishment costs were assumed the same as initial unit costs regardless of the sand quantity required, schedule of nourishment, or economies of scale.

The projects are also formulated with the following general rules in mind as they apply to South Carolina:

- The cost of sand is higher in the Grand Strand because of transport distance and more limited availability than other parts of the coast.
- Trucking from inland is generally more expensive per yard than dredging from nearby deposits.
- Trucking from accreted shoals is generally less expensive per yard than dredging for small to medium size projects or where the fill is thinly spread over a long section of beach.

Many of the projects could be constructed by truck or dredge. The most cost-effective method and sand source are listed, based on the above general rules. Some projects may use a dredge for the initial nourishment and then use trucks for the maintenance nourishment, in which case both methods may be listed.

There are also situations where several construction techniques cost about the same, making it advisable to request bids by alternate methods and allow contractors to designate the optimal transfer method and borrow source. Among the innovations mentioned in the past for use in the Grand Strand are conveyors to move the sand from borrow pits across the Intracoastal Waterway to central stockpiles near the beach.

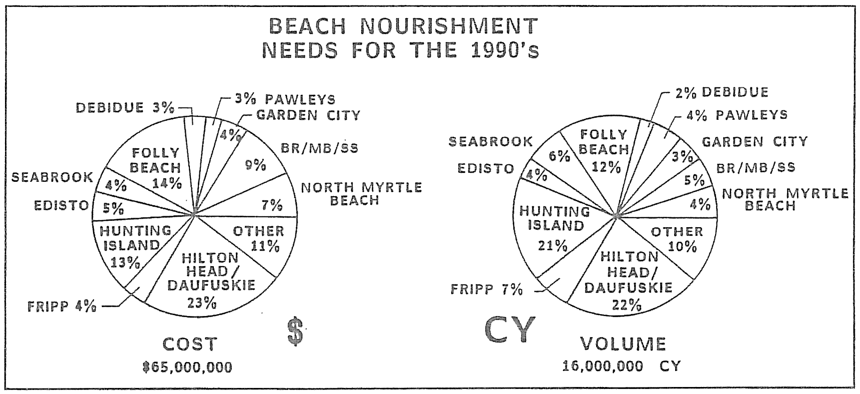
Predicted Nourishment Needs For The 1990s

Using a consistent set of criteria, the state's nourishment requirements over the next ten years are estimated below. The estimate differs from certain projects in planning, such as the U.S. Army Corps of Engineers' Grand Strand project, because the design goals may be different. However, by considering the needs and costs on a site-specific basis under consistent criteria, it is possible to rank each project in terms of unit as well as total costs.

Of the 90 miles of developed oceanfront in South Carolina, about 54 miles are eroding to some degree. In the Grand Strand, the problem has as much to do with encroaching development as the general but slow retreat of the shoreline. Along Hilton Head, Hunting and Fripp Islands, by comparison, most of the erosion occurs at the center of these islands while the ends of the islands gain sand. The erosion on Seabrook Island is attributed to the movement of an unstable tidal inlet which interferes with the steady flow of sand from Kiawah. Much of the erosion along Folly Beach is attributed to the Charleston Harbor jetties, structures that impede the flow of sand to Folly Beach.

The state's developed, eroding beaches have been divided into 18 distinct reaches as given in Table 5 and illustrated by the pie charts. Reach by reach, the sand deficit (initial nourishment requirement) and annual sand loss (maintenance nourishment requirement) have been estimated from recent surveys by the South Carolina Coastal Council and others to arrive at a total yardage required over the next ten years (see appendix for details). Unit costs of sand for each reach are based on the nearest known sand source and experience from other projects. This yields a project-by-project total cost and a cost per foot of shoreline based on the length of each project.

Table 5 shows 18 beach nourishment projects (plus contingency) that may be needed in the 1990s, comprising about 16 million cubic yards at a cost of $65 million. This is the level of effort necessary to restore and maintain an average 50-foot-wide, dry-sand beach along the developed coast. The average of all projects would represent an expenditure of about $230/ft of eroding shoreline. Unit sand costs will be highest in the Grand Strand, reaching as much as $8.50/cy (1990 prices) in Briarcliffe where there is no convenient access to the sand source. Unit costs will be lowest at Seabrook Island, Isle of Palms, and Sullivans Island where nearby sand sources are available (assuming permission to use nearshore or accreted shoals is forthcoming from the regu-



latory agencies and local communities). On a per foot basis, the most expensive projects will be Folly Beach, Hilton Head, and Hunting Island; the least expensive will be Seabrook's north beach, using inlet relocation for nourishment, and Myrtle Beach, which will only require small-scale maintenance after its two nourishment projects. (Tables 2 and 4)

It can be seen from Table 5 that three projects, Folly Beach, Hilton Head Island and Hunting Island, may require almost one-half of the total budget for projects while representing about one-fourth of the state's eroding shoreline. Other large projects in terms of cost are North Myrtle Beach, Edisto Beach, Fripp Island, and Garden City. Approximately 10 percent contingency is included to account for possible additional areas or greater requirements.

Tables 6 and 7 group the projects by region and private areas, respectively. Table 6 shows total costs for the Grand Strand projects (North Myrtle Beach to Garden City) at $12.5 million (19 percent of total) at a relatively cost-effective $127/ft of shoreline. By length, the Grand Strand projects make up over one-third of the eroding shoreline. If Folly Beach is excluded, the cost of nourishment in Charleston County would be less than one-half the Grand Strand's with most of this going to Edisto Beach. Isle of Palms and Sullivans Island are both accreting beaches but experience occasional problems around the inlets because of sand-trapping by shoals. Low-volume, maintenance nourishment is assumed for both places using sand from accreted shoals. Beaufort County, encompassing Hunting, Fripp, Hilton Head, and Daufuskie Islands combined, would require about 50 percent of the nourishment volume with the majority going to Hunting Island and Hilton Head Island.

Private projects (Table 7) are defined as those islands/reaches having restricted beach access. These include DeBordieu Island, Wild Dunes, Seabrook, Fripp Island, Palmetto Dunes on Hilton Head Island, and Daufuskie Island. Before public funds are used here, public access goals must be met. The private projects represent about 22 percent of the estimated total cost and 27 percent of the total sand volume requirement.

TABLE 5. South Carolina beach nourishment requirements--estimated 10-year project needs (1990s).

Locality	Length (ft)	Volume (cy)	Unit Cost	Total Cost	Cost/ft	Method (Source)
North Myrtle Beach	35,000	665,000	6.50	4,322,500	123.50	DR/TR (E/AS)
Briarcliff/Horry County	10,000	210,000	8.50	1,785,000	178.50	TR (E)
Myrtle Beach*	25,000	250,000	7.00	1,750,000	70.00	TR (E)
Surfside/Horry County	15,000	277,500	7.50	2,081,250	138.75	TR (E)
Garden City	13,500	513,000	5.00	2,565,000	190.00	DR/TR (E/AS)
Huntington Beach*	5,000	100,000	4.00	400,000	80.00	TR (AS)
Pawleys Island	15,000	570,000	3.50	1,995,000	133.00	TR (AS)
DeBordieu Island(1)**	8,000	356,000	5.00	1,780,000	222.50	TR (E)
Isle of Palms	4,000	120,000	2.50	300,000	75.00	TR (AS)
Sullivans Island	2,500	117,500	2.50	293,750	117.50	(TR (AS)
Folly Beach/FB Park**	20,000	1,840,000	5.00	9,200,000	460.00	DR (E/AS)
Seabrook Island(1) (south beach)	6,000	738,000	2.50	1,845,000	307.50	DR (E)
Seabrook Island (north beach)	12,000	168,000	3.00	504,000	42.00	Inlet Relocation
Edisto Beach	15,000	645,000	5.00	3,225,000	215.00	DR/TR (E)
Hunting Island**	16,500	3,300,000	2.50	8,250,000	500.00	DR/TR (E/AS)
Fripp Island(2)	12,000	1,080,000	2.50	2,700,000	225.00	DR/TR (E/AS)
Hilton Head Island**	35,000	2,940,000	4.50	13,230,000	378.00	DR (E)
Daufuskie**	9,000	594,000	2.50	1,485,000	165.00	TR (AS)
Contingency	26,500	1,516,000	4.80	7,288,500	275.04	
[54 mi]	**285,000 ft**	**16,000,000 cy**	**$4.06/cy**	**$65,000,000**	**$228.07/ft**	

DR = dredge. TR = trucks. E = external source. AS = accreted shoals. [Source: Coastal Science & Engineering, Inc., March 1990]

*Maintenance nourishment only; no initial requirement.

**High erosion rates in these areas suggest groins/breakwaters should be considered.

(1)In construction, March 1990.

(2)A larger scale dredging project involving 1,500,000 cy at a cost of $4.5 million has been proposed by CSE to develop a longer term solution.

TABLE 6. Beach nourishment needs in the 1990s by region.

Locality (Number of Projects)	Length (ft)	Volume (cy)	Unit Cost/cy*	Total Cost	Cost/ft**
Grand Strand (5)	98,500	1,915,500	6.55	12,503,750	127
Georgetown County (3)	28,000	1,026,000	4.05	4,175,000	149
Folly Beach (1)	20,000	1,840,000	5.00	9,200,000	460
Charleston County (5)	39,500	1,788,500	3.45	6,167,750	156
Hunt/Fripp (2)	28,500	4,380,000	2.50	10,950,000	384
Hilton Head/Daufuskie (2)	44,000	3,534,000	4.16	14,715,000	334
Contingency (±10%)	26,500	1,516,000	4.80	7,288,500	275
[54 mi]	**285,000 ft**	**16,000,000 cy**	**$4.05/cy**	**$65,000,000**	**$228/ft**

*Rounded to nearest $0.05. **Rounded to nearest $1.00.

[Source: Coastal Science & Engineering, Inc., March 1990]

TABLE 7. Beach nourishment needs in the 1990s--private projects.*

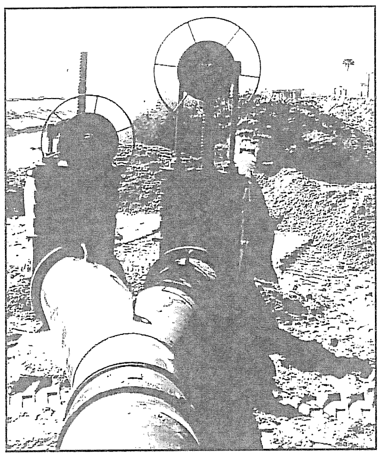
Locality	Length (ft)	Volume (cy)	Cost/cy	Total Cost	Cost/ft	Method (Source)
DeBordieu Island	8,000	356,000	5.00	1,780,000	222.50	TR (E)
Wild Dunes (Isle of Palms)	4,000	120,000	2.50	300,000	75.00	TR (AS)
Seabrook Island	6,000	738,000	2.50	1,845,000	307.50	DR (E)
Seabrook Island	12,000	168,000	3.00	504,000	42.00	Inlet Relocation
Fripp Island	12,000	1,080,000	2.50	2,700,000	225.00	DR/TR (E/AS)
Palmetto Dunes (Hilton Head Island)**	35,000	2,940,000	4.50	13,230,000	378.00	DR (E)
Daufuskie	9,000	594,000	2.50	1,485,000	165.00	TR (AS)
Subtotal	**66,000 ft**	**4,316,000 cy**	**$3.31/cy**	**$14,284,000**	**$216.00/ft**	
(Percent total)	(23)	(27)		(22)		

DR = dredge. TR = truck. E = external source. AS = accreted shoals.
*Defined as sites where beach access is restricted from the land side.
**Pro rata - Palmetto Dunes - 43 percent of total project.

[Source: Coastal Science & Engineering, Inc., March 1990]

Summary

WHILE BEACH EROSION IS A PROBLEM IN South Carolina, it can be managed cost-effectively in many areas through nourishment. Where gradual retreat, cornerstone of the 1988 Beachfront Management Act , is not practical given the size and investment of buildings, nourishment may be the only alternative left to conserve those beaches.



It is estimated that 16 million cubic yards of sand, costing around $65 million, will be required to restore and maintain a minimal dry-sand beach along our eroding shoreline during the next ten years. Nourishment requirements and costs will be greatest at Hilton Head Island, Hunting Island, and Folly Beach. With unit costs approaching $500 per foot of shoreline in some areas, the expense will be comparable to constructing seawalls. In many cases, the cost of nourishment will be less than armoring and a fraction of the value of existing development.

The estimated ten-year nourishment cost for the Grand Strand is about $125/ft of shoreline. Given the fact that this region's oceanfront property has sold as high as $10,000/ft of shoreline in recent years, the relative cost of nourishment should be low. Further experience after the 1987 New Year's Day storm and Hurricane Hugo demonstrates how nourished beaches reduce storm damage, confirming the value of healthy beaches.

At the other extreme, Folly Beach's ten-year needs exceed $450/ft of shoreline; here, oceanfront property values presently average around $1,500/ft. At some point, economics must rule, and it may be more cost-effective to implement a solution that combines nourishment with selected retreat and construction of larger sand-retaining structures.

Overall, the nourishment needs along the South Carolina coast are no different than other states. Some beaches are worse off and will require more sand, whereas others are healthy or lack development and do not require any remedial action. Unfortunately, attention seems to focus on the developed, eroding beaches in South Carolina and other states. There are numerous beaches worldwide that are healthy and undeveloped. Furthermore, development along the coast is not necessarily bad. Most of us cannot readily get to undeveloped beaches, and besides, almost everyone favors convenient places to stay when they visit the shore. The goal is to maintain a balance between development and the beach.

For the most part, South Carolina has maintained this balance. This state's coast has more diversity than any place along the East Coast; from intense development to pristine wilderness, from rapid erosion to continual accretion, from crowded places to solitary refuges. This diversity in a large part can be attributed to the numerous inlets that separate the many regions. Unlike many coastal states, these inlets contain huge sand reserves that may hold the key to the shoreline's future and may provide an alternative source in some cases to other offshore and inland sand sources. Within limits and through careful planning, some of this sand can be tapped and used to conserve our beaches for future generations. It will not be without costs, but is there a better way?

Appendix

GENERAL

All projects formulated using the concept of an initial nourishment requirement to make up existing sand deficits to profile closure [-12 ft to -15 ft NGVD (approximate mean sea level) in South Carolina] and restore a minimum 50-ft dry-sand berm width after fill adjustment to natural beach and nearshore slopes for the area. Maintenance nourishment is determined based on surveyed erosion rates from profiles (where available) or estimation of volumetric erosion rates (to closure) from linear erosion rates. Initial and maintenance requirements given as averages for the reach in question. Note in many cases, a range of erosion rates and deficits occur within a reach; therefore, the average applied is lower than the peak rate for an area (e.g., Hilton Head,DeBordieu, etc.). Design berm elevation is based on normal limit of wave uprush during spring tides which is +6 ft to +8 ft NGVD along the South Carolina coast. The ten-year design does not relate to ten-year peak water levels, rather to the expected rate of erosion of the berm and sand volume in the profile. Such nourishment volumes will not prevent damage during all moderate storms or safeguard dunes in all cases. But it will provide adequate volume for natural processes to restore the profile after storms and maintain a healthy exchange of sand between the beach and nearshore area.

• North Myrtle Beach

Estimate 80 percent (35,000 ft) requires nourishment. Initial requirement averages 10 cy/ft; annual maintenance at 1 cy/ft for nine years; total fill over ten years is 19 cy/ft/ Possible sand sources are Little River Inlet shoals, Hog Inlet shoals, and spoil deposits along ICWW. Emergency project (377,200 cy) in 1989 generated cost data. Unit-cost estimate is well above 1989 emergency work because a larger source required than Hog Inlet shoals.

• Briarcliff/Unincorporated Horry County

Estimate 10,000 ft requires nourishment, particularly hotel section near Hilton Hotel. Profiles indicate initial deficit is 12 cy/ft and annual erosion is 1 cy/ft; total fill requirement over ten years is 21 cy/ft. Possible sand source is inland spoil deposits along ICWW. Construction by trucks because of small project size. Unit costs assumed high because of haul distance. Unit price based on quotes for comparable haul during the Surfside and North Myrtle Beach emergency nourishment projects.

• Myrtle Beach

Site of 853,000 cy project in 1986-1987 and 380,000 cy project after Hugo. Assume 55 percent (25,000 ft) will require maintenance, particularly the hotel district between 60th and 77th Avenues North and the area from 31st Avenue North to 29th Avenue South. Maintenance estimate at 1 cy/ft/yr for the reduced project length; total ten-year requirement is 10 cy/ft over 25,000 ft. Sand source is inland spoil pits off ICWW. Unit costs based on bid price for 1989 project.

• Surfside Beach/Unincorporated Horry County

Estimate 15,000 ft has initial deficit of 5 cy/ft (after emergency project) and annual erosion at 1.5 cy/ft/yr for nine years; total fill requirement is 18.5 cy/ft. Sand source is assumed to be inland spoil pits off ICWW. Unit costs based on the February 1990 bid for the emergency project.

• Garden City

Estimate 13,500 ft require nourishment, primarily around Kingfisher Pier area. Initial deficit assumed to be 20 cy/ft based on post-Hugo profiles and allowance for emergency fill. Estimated erosion rate at 2.0 cy/ft/yr for nine years; total fill requirement is 38.0 cy/ft over ten years. Sand source is assumed to be inlet and attached shoals at Murrells Inlet and construction by dredge and/or trucks. Unit costs estimated from past dredging cost (Huntington Beach, significantly lower) and the emergency project (significantly higher).

- **Huntington Beach/Litchfield**

Essentially a healthy beach except for localized erosion downdrift of Murrells Inlet jetties. Presently no deficit because of 1988 inlet maintenance project (450,000 cy). Assume 5,000 ft will require future maintenance based on 2.0 cy/ft/yr erosion rate (which may accelerate after Year 2000 as the effects of the jetties become more pronounced); total fill requirement is 20 cy/ft. Borrow source is Murrells Inlet shoals. Project may be done as part of the scheduled maintenance for the navigation project.

- **Pawleys Island**

Estimate initial deficit along 15,000 ft of shoreline (all but north end) at 20 cy/ft based on post-Hugo surveys and following emergency nourishment. Annual erosion rate estimated at 2.0 cy/ft/yr; total fill requirement is 38 cy/ft. Borrow sources are attached shoals at Midway Inlet and Pawleys Inlet (same source used in 1988 and 1989 projects). Construction proven by land based equipment. Unit costs based on 1988 and 1989 experience.

- **DeBordieu Island**

Estimate initial deficit over 8,000 ft of developed shoreline at 22 cy/ft; annual erosion rate estimated to average 2.5 cy/ft/yr; ten-year requirement is 44.5 cy/ft. Borrow source is assumed to be inland pits. Unit costs based on small-scale project experience in October 1989. [Note: An initial project totaling 180,000 cy was completed in April 1990 at a cost averaging about $4.50/cy.

- **Isle of Palms**

Estimate that localized erosion may occur along 4,000 ft of shoreline due to shoal movement around Dewees Inlet (similar to events in 1982 and 1985). There is not initial deficit, but localized erosion is assumed at 3.0 cy/ft/yr in the One adjacent to future shoal attachments. Total fill requirement is 30 cy/ft or 120,000 cy. Borrow source is assumed to be accreted shoals if such localized erosion occurs because of the healthy condition of the beach. Past experience proves the project is feasible by trucks at low unit costs.

- **Sullivan's Island**

Estimate that local problems will persist along Breach Inlet because of the tendency for southward migration. Initial deficit over a 2,500-ft reach on the inlet is 20 cy/ft based on profiles; annual erosion is estimated at 3.0 cy/ft/yr (short groins lessen the natural rate); total fill requires averages 47 cy/ft.

- **Folly Beach/Folly Beach Park**

Estimate initial deficit is 65 cy/ft along 20,000 ft of shoreline; annual erosion rate estimated at 3.0 cy/ft/yr (groins reduce the natural rate); total fill required is 92 cy/ft. Borrow source is assumed to be updrift shoals of Stono Inlet or shoals of Lighthouse Inlet and construction by dredge given the large initial fill requirement. Unit costs based on project experience from similar sites.

- **Seabrook Island (1)**

Estimate south beach (6,000 ft) has a deficit of 123 cy/ft or 738,000 cy total. Because of a sand surplus to the north and an historical trend of southerly transport, it is assumed natural accretion will replace fill losses and stabilize the project for ten years. Borrow source is the landward end of the north shoal of North Edisto Inlet which is causing part of the erosion problem by forcing a channel into the beach. The project must accomplish removal of a portion of the shoal, realignment of the channel, and restoration of the beach to be successful. Estimated cost is $2.50/cy based on bids (December 1989). [Note: Project was completed in March 1990 at a cost of $1.55 million for a total of 685,000 cy.]

- **Seabrook Island (2)**

Estimate north beach will erode by mid 1990s unless Captain Sams Inlet is relocated again (similar to 1983 project). There is no sand deficit, but about 168,000 cy must be excavated to relocate the inlet a second time. Timing of the project should be based on surveys in anticipation of the time lag between erosion and natural recovery after inlet relocation. Postproject data from the 1983 relocation are available on which to base the second relocation. Borrow source would be Kiawah spit where the proposed inlet relocation is planned. Total costs are based on past experience plus allowance for inflations at 8 percent per year through 1996.

- **Edisto Beach**

Estimate 15,000 ft from the park south requires nourishment. Initial deficit is 25 cy/ft based on surveys; annual erosion averages 2.0 cy/ft/yr; total fill requirement over ten years estimated at 43 cy/ft. Borrow sources assumed to be inland pits and the shoals at the south end of the island in St. Helena Sound. Costs based on prices for comparable dredging projects.

- **Hunting Island**

Estimate 16,500 ft (80 percent of the island) sustains annual loss of 18 cy/ft/yr and the initial deficit is 38 cy/ft for a unit fill requirement of 200 cy/ft (Source: CSE, 1990, Feasibility Study of Beach Restoration Alternatives for Hunting Island). Total fill requirement would be 3.3 million cubic yards or 2.4 times the volume placed in the 1980 project. The total requirement is similar to the volume placed in four projects over 12 years between 1968 and 1980 (3.54 million cubic years). Borrow source could be offshore deposits as confirmed in recent surveys or the inlet shoals at Fripp Inlet and Johnson Creek, some of which are accessible by landbased equipment. Costs are based on past project experience at Hunting Island and recent bids for the Seabrook and Hilton Head nourishment projects. At the time of this writing (fall 1990), a budget-limited project involving ±1 million cubic years as in planning by the South Carolina Department of Parks, Recreation and Tourism.

- **Fripp Island**

Estimate 12,000 ft of shoreline principally in center of the island have an initial deficit of 45 cy/ft; annual erosion is estimated at 5.0 cy/ft/yr in the erosion zone; total fill requirement is 90 cy/ft. Borrow source is assumed to be attached shoals at the north end of Fripp Island. Sand can be borrowed by using land-based equipment and transported at relatively low cost to eroding sections. Unit costs based on comparable projects. [Note: A larger project involving twice as much fill has been proposed as a longer term solution that may reverse the erosion trend. It would require excavation of a large portion of the Fripp Inlet shoal attached to Fripp island to reduce the sand transport reversal (which causes sand from the center of the island to shift back to Fripp Inlet). By realigning the shoreline from inlet to inlet, the present causes of erosion would be diminished and produce a more permanent project. The estimated ten-year project given in this booklet is not considered a permanent solution that will alter the basic causes of erosion at Fripp.]

- **Hilton Head Island**

A 2.5 million cubic yard project, scaled back at the time of the bid to about 2,036,000 cy, was designed to nourish 35,000 ft along central Hilton Head Island. The design estimated an eight-year life. For the present ten-year nourishment requirement, it is estimated the initial deficit is 30 cy/ft and annual erosion is 6 cy/ft/yr; total fill requirement for a ten-year project is estimated at 84 cy/ft. Borrow source is assumed to be offshore shoals at Joiner Bank, Gaskin Bank, or Calibogue Bank as recommended in the designed project. Unit costs are based on bids. [Note: The nourishment project began in

April 1990 and was completed in August; the schedule called for 57 cy/ft in the project area. Actual delivered volume was close to 2.5 million cubic yards (±70 cy/ft) according to dredging records.]

- **Daufuskie Island**

Estimate 9,000 ft along central Daufuskie have a deficit of 30 cy/ft; annual erosion is around 4.0 cy/ft/yr; total fill requirement over ten years would be 66 cy/ft. Borrow source is assumed to be low-tide shoals along the oceanfront which are part of the delta complex of Calibogue Sound. It is assumed landbased equipment or draglines could be used to excavate and place the materials at relatively low unit costs of $2.50/cy.

CONTINGENCY

Given uncertainties in any analysis such as this, it was assumed that an additional 10 percent of the project needs (in terms of shore length and sand volume) should be added to the above list of projects. This equated to ±26,500 ft and ±1,516,000 cy. Unit costs were assumed in the median range of $4.80/cy. When combined with the specific projects, the contingency total yields round figures for total costs and yardage required.

SOUTH CAROLINA COASTAL COUNCIL

Conserving What We Can't Create